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Final Report

ERIM PROCESSING AND ANALYSIS ACTIVITIES

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This report summarizes the data processing and analysis activities performed at ERIM over the past year. This work has included quick-look optical and digital processing of P-3/SAR data, analysis of digital data, implementation of a spotlight SAR processor, and deployment of a radar reflector calibration array. Each of these activities, as well as other technical contributions are described.

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1.0 INTRODUCTION

Several activities were conducted over the past year in support of the P-3/SAR system. Recall that the P-3/SAR is a three-frequency Synthetic Aperture Radar (SAR) which was developed at the Environmental Research Institute of Michigan (ERIM) and is housed in a Naval Air Development Center (NADC) P-3 aircraft.

These activities included: quick-look optical and digital processing, near-term digital analysis, processor upgrades for non-conventional SAR modes, and deployment of a calibration array. Each of these activities were in support of a classified data collection experiment conducted in May/June 1990 by the P-3/SAR and are described below.

In addition to the activities listed above, ERIM scientists also played a key role in both the design and execution of last year's test. Finally, this contract has supported the participation of an ERIM scientist on an advisory panel established by the Navy. These activities will also be described below.

2.0 RESEARCH DESCRIPTION

Presented below is a brief summary of the activities performed at ERIM in support of this program. Publications resulting from this work are referenced as appropriate.

2.1 QUICK-LOOK OPTICAL PROCESSING

During last year's experiment, a single channel of optically-recorded data was shipped to ERIM immediately following each flight where it was processed into imagery and examined for features of interest. The results of this effort were disappointing. The generally low quality of the optically-processed imagery prevented us from making any conclusions about target detectability. Subsequent to the test, the optical recorder onboard the P-3 was removed with no replacement plans.

An alternative method for surveying data sets is to utilize the High Density Digital Tapes (HDDT's) recorded by the P-3/SAR to create signal films. These films can then be processed quickly into imagery. This digital optical technique has several advantages over the optically-recorded signal films. The digital data is inherently less noisy then the optical. This method also allows us to quickly screen the digital data, and we are no longer limited to a single channel. We are recommending that future data collection experiments utilize this capability to provide a survey of the data set.

2.2 QUICK-LOOK DIGITAL ANALYSIS

Also during last year's test, a subset of the digitally-recorded data was shipped to ERIM after each flight. This data included synthetic targets and passes made over a corner reflector array. The synthetic targets were used to test the transmitted pulse form and the motion compensator. Histograms of the synthetic target phase history were generated to check for saturation. In addition, we processed the synthetic targets into imagery as a check on the image formation software.

The phase history data collected over an array of corner reflectors was also processed into imagery. Details on this array are given in Section 2.5. Measurements of sensor resolution were made using the reflector data to provide an estimate of sensor health. One problem which was confirmed during the experiment was a misalignment of the antenna pointing angle in azimuth. This was observed as an offset in the Doppler spectrum calculated from the phase history. This pointing error was subsequently corrected.

Example imagery and measurements from the quick-look digital analysis were utilized to evaluate the performance of the P-3/SAR during last year's test. These results are found in Przeslawski (1991).

2.3 NEAR-TERM DIGITAL ANALYSIS

Over 100 images have been processed from last year's test. These data have been utilized to study several research topics including; statistical analysis of the ambient background data; cataloguing of signal characteristics as a function of distance from the target and look angle; estimation of signal strength as a function of both distance from the target as well as the radar look angle and how to utilize these quantities to estimate increased signal strength using a "sliding spot" collection mode; and utilization of the spotlight data to estimate increases in signal detectability by exploiting temporal information; and comparison of SAR images of ocean waves for different look angles with theoretical predictions to test SAR imaging theories. Each of these studies is described in Wackerman, et. al., (1991).

2.4 PROCESSOR UPGRADES

Due to the small turn around time required for installation of the L-band spotlight mode on the P-3 aircraft, it was decided to implement the spotlight data processor as a modification to the existing stripmap spotlight processor. This implied that a convolutional approach would be adopted as opposed to a polar-formatting approach. Such an approach has the additional advantage of easily handling the short pulse length (as compared to the recorded range record) and accommodates different integration times for a given image. The modifications that were required to the existing processor involved solving the large range walk problems that would be encountered, especially at large squint angles, and handling the changing nature of the responses as a function of azimuth location. The first problem was addressed by introducing a skew in the data to remove the linear term of the range walk and thus reduce the problem to the original stripmap case, where the quadratic component of the range walk has to be dealt with anyway. The second problem was solved by doubling the size of the azimuth filter so that each response would correlate with the filter at a different location, and thus a single filter could be used for all of the different azimuth responses. For more details about the actual implementation see Wackerman, et. al., (1991).

The new processor was tested on simulated point target data to work out any software bugs, and then was run on data collected over land targets. A video was made of output images as a function of look angle which showed that adequate image resolution was being obtained, and demonstrated the added advantage of the spotlight mode in generating time series data for a given spatial location; the video clearly shows the changes in radar cross section as the sensor flies by. After passing these software tests, two data sets were processed, Run 914 Pass 2 and Run 908 Pass 2, and a series of images generated for each over the range of squint angles from -45 to 45 degrees. Videos for each of these data sets were also made, and analysis performed on signal strength changes with look angle, clutter changes with look angle, and the utilization of the spotlight mode to maximize signal detectability. These analyses are discussed in detail in Wackerman, et. al., (1991).

2.5 CALIBRATION ARRAY DEPLOYMENT

In support of last year's experiment an array of calibrated radar corner reflectors were deployed near the test site. The reflectors were deployed in two configurations: (1) a radiometric array to be observed in stripmap mode, and (2) two large reflectors to be observed in L-band spotlight mode. The radiometric array consisted of 12 triangular trihedral reflectors ranging in size form 45 to 90 cm. The two spotlight reflectors were 1.07 m trihedrals.

The P-3/SAR imaged each set of reflectors in the appropriate mode during each data collection day. These data were used to verify system resolution and linearity as previously discussed in Section 2.2. A summary of the array deployment and example image measurements is given by Sheen, et. al., (1991).

2.6 OTHER ACTIVITIES

In addition to the efforts described above, ERIM made several other significant contributions to the program last year. These included making detailed recommendations on how to operate the P-3/SAR during last year's experiment. These were generated by marrying the objectives of the test with the capabilities of the P-3/SAR. Several test flights were performed to verify that the P-3/SAR could collect useful data in previously untested geometries. These recommendations were included in the Science Plan for the test (Schemm and Elliott, 1990).

ERIM also provided a scientist on-site during the experiment who helped coordinate the P-3 data collection flights. This included modifying flight lines and system operating parameters based on changing conditions or run parameters.

ERIM also had a member on the Navy's Technical Review Group (TRG) which was formed in 1990 with the purpose of reviewing the program results and making recommendations on future efforts. In addition to attending the quarterly TRG meetings, ERIM provided several technical briefings to the TRG and hosted one of the meetings.

3.0 REFERENCES

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